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USING CONSULTANTS TO EXPAND A HIGHWAY PROGRAM

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HIGHWAY DIVISION

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USING CONSULTANTS TO EXPAND A HIGHWAY PROGRAM[1]

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Consulting engineers can be used effectively as an expedient in promoting a highway program. Especially is this true when efforts to achieve goals of an expanded program exceed capacities of regular personnel and facilities of the existing highway organization. Experiences carrying forward Missouri's current 10-year state highway modernization and expansion program certainly bear out such conclusions.

The word "expedient" is used purposely. It is much more desirable to do all work with your own forces. You can do it cheaper and more to your satisfaction. But, in view of current shortages in trained technical personnel and the resulting highly competitive market for their services, highway departments, limited as they are on salary scales, are at a disadvantage when they seek to enlarge their staffs.

That is true in Missouri, at least. It applies almost everywhere. Thus, consultants offer a solution to the problem, characterized by mere utility rather than principle — they offer a means to supplement available staffs.

The Missouri State Highway Commission has been employing consulting engineers on a limited scale since the early 1930's. Until 1951, however, their use was confined to design plans for bridge structures. In each case they were retained because circumstances of one cause or another did not permit, or made it unfeasible, to expand the staff to handle the particular project at hand.

The postwar period and its mounting urgency for highway modernizations found the Commission hard-pressed for sufficient personnel and facilities to meet all road survey and design needs. Because, for the most part, experience with consultants in furnishing bridge design plans had been successful, it was decided in 1951 to experiment by using them on road survey and design, contracting two such projects.

Then, in 1952, the General Assembly enacted legislation to provide additional highway revenues to finance a 10-year program during which time an estimated $557-1/2 million dollars would be spent on construction to meet minimum highway needs. Necessarily the volume of work connected with getting such a program rolling taxed the Department's facilities.

The Commission had been looking forward to the time when monies would be available to modernize the state's highways, and fit them to current needs. As a result of that forward thinking, it did have a sizeable backlog of survey work done and designs completed. However, after it put those under contract it was forced to follow almost a hand to mouth policy — complete a road design one day and contract it the next.

Then came indications that additional federal aid would be forthcoming, possibly in a considerable amount. Missouri's Commission wanted to be

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1. Paper presented at the St. Louis Convention, ASCE, June, 1955.
2. Chf. Engr., Missouri State Highway Comm., Jefferson City, Mo.

ready to take early advantage of any such program. When it became evident it would not be able to expand its staff sufficiently and quickly enough to do this, it increased its use of consultants.

As a result, it now has employed, from time to time, a total of about 25 consulting engineering firms on various road and bridge survey and design projects. Fees on contracted projects, if all are completed as planned, will total about $3-1/2 million dollars. For the most part it has found the practice satisfactory, and again is added "as an expedient," and it may find it necessary to contract even more such projects in the future.

Because increased use of consultants has stemmed primarily from the abnormal engineering demands of the 10-year state highway program, most of this treatise will deal with experiences since that program got under way. Some examples prior to that date will be used, to help bring out certain points.

Earliest experience in using consultants was for bridge design. Let's examine that first. The Missouri Highway Department's Division of Bridges is not a small set-up by any means — It has a staff of 35 men in the design office. Under normal conditions such a staff has been able to handle most design demands, with a lift now and then, usually on some selected, large project.

The 10-year state highway program carries three separate phases which must be handled concurrently — modernization of our major system routes outside of urban areas, urban improvements to alleviate traffic congestion in the cities, and the addition of some 12,000 miles of roads to our existing supplementary highway system. Necessarily the demands of carrying out such a program cannot be classed as normal.

First, many of the bridge structures on existing major system routes already were obsolete, or were becoming so when the program got under way. Certainly the program could not progress unless such structures were widened, replaced or given the necessary attention to fit them to current traffic demands on their particular highway. This phase in itself mounted a considerable work load.

The urban phase brought additional burdens to the division of bridges too, because numerous grade separations and elevated expressways were or will be necessary as such projects go forward. In the larger cities design for some of these structures has been and is especially intricate, requiring much complicated design and detail work and many tedious man hours to complete.

The supplementary phase also represents a tremendous hurdle. To attain the goal of 12,000 miles of roads it proposes to add to the existing highway system, the Commission is committed to build some 3,500 miles by outright construction and to take over some 8,500 miles of existing county roads for maintenance and develop them to state highway standards.

Bridge structures must be designed from scratch on all roads falling in the "new construction" category. No exact count has been made, but it has been estimated that some 4,000 other stream crossings are included in the takeover part of the program. Each will require some type of attention from the bridge forces, to make certain it is both adequate and safe for traffic using that road. Many of those crossings will have to be replaced with new structures. Others will need to be widened, lengthened or strengthened. All of them will require design plans. Lesser work must be made on structures needing only repairs.

Bid calls the first six months of this year provide an excellent example of

the scope of the task. Through June the Commission asked and received bids on more than 175 bridge structures of 20 feet or more in length, with a goodly number being quite sizeable spans. It had 57 in the January call, 22 in February, 26 in March, 47 in April, 26 in June.

Also, with more attention being focused on high and early development of interstate routes, still more burdens seem certain to be heaped upon the bridge staff. Suffice to say that when you must build two bridges over each stream for a divided highway, two more over the same streams to provide for outer roadways, and grade separations at the side roads, bridge design demands necessarily will soar.

These problems all have been given serious thought by bridge engineers, personnel section and commission. Every effort has been pointed to be sure program requirements can be met. To that end the design staff has been enlarged and more working space now is being added, not only for the Division of Bridges but for the entire Main Office organization, by enlarging the Main Office building. But it still has been impossible to obtain all the personnel necessary.

So, to supplement efforts of the regular staff contracts have been made for design plans on about 25 bridge structures since this program got under way July 1, 1952. It can be said, and with no small measure of state pride, that Missouri has one of the finest of bridge design units. It is capable of designing any bridge structures the state highway system requires, regardless of size.

However, as Commission engineers set about to select those structures on which to contract design plans it was decided the program could be best promoted by letting out those requiring the greatest amount of detail work. This would leave regular forces more free to attack the balance of the task at hand. As a result, projects contracted have included two new spans across the Missouri River — At Jefferson City and St. Charles —, several urban grade separations and elevated expressways in St. Louis and Kansas City, and other outstate projects.

To make sure that negotiated prices made are in line with current fees being charged, engineers are assigned to analyze each offer made and compare it with the regular forces cost estimates. Contract costs on bridge design projects so far have ranged from $2,250 to $212,500, with total fees over the period being about a million dollars.

Experience in contracting road study, survey and design to consultants is much more recent than for bridges. In fact, until the 10-year program was launched in 1952 the Division of Surveys and Plans forces had been able to meet all such needs. Here again, though, limited manpower and a vastly expanded program caught up with capacities. That is seen readily when one noted that since the program got under way Missouri has improved, one way or another, some 8,000 miles of state highways.

With such a work demand, and because experiences on bridge design work had proved out through the years, the Commission turned again to consultants. To this date it has contracted for about 600 miles of various type work — engineering study, aerial and ground surveys, plans designing. If all the projects now under contract are carried out, fees to the consultants will total about $2-1/2 millions for roadways alone.

Introduction to the use of consultants for road design was not an auspicious one. Two projects were contracted in 1951. One was for survey and design plans on an approximate two mile section of a U. S.— marked route. The other was for 10-1/2 miles of like work on a state-marked major system route.

The small project was completed satisfactorily. The longer one saw delay after delay, with the work not only progressing slowly but most unsatisfactorily. Finally, when the job still was not complete late last year the district office was forced to cancel the contract and complete 1-1/4 miles of the project. Final payment to the consultant for work he had done was made only in January of this year.

That project has been the only one in which complete dissatisfaction has been experienced. Actually, use of consultants has proved to be more and more worth while as experience has been gained in applying their services to Commission purposes. This results, most probably, because you are continually able to give them a better picture of the scope of work they are to do, and they thus have been better able to understand your needs and plan accordingly to meet them.

Because consultants have been used on roadway survey and design only more recently, no complete picture is available as yet on any of the larger projects contracted. In some instances the work seems to be moving more slowly than it should. The hope is, however, this picture will change as the projects move forward.

Just as in the case of bridge work, contracted roadway survey and design projects have included roads from all three phases of the current 10-year program. More recently a number of special sections on interstate routes were selected for contracting, in the belief such a plan would return the greatest dividends.

Proof that the Highway Commission believes such a program is advisable is found in its order giving authority to negotiate such contracts for all interstate route work yet to be done. By contracting such work now, it is hoped to have all preliminaries out of the way so Missouri can take immediate advantage of any stepped up federal program the Congress may authorize.

Some of the larger interstate projects contracted to consultants include the surveying, plotting and inking plans and completing design on 42, 28 and 48-mile long sections of U. S. Route 40. These contracts all were made in February of this year. A similar contract was awarded for eight miles on U. S. Route 66 in April. Another covers a preliminary study of 85 miles of U. S. Route 61, contracted in March. There also is a roadway contract going on U. S. Route 71 and other contracts for roadway work are pending.

Likewise, projects are under way on planned urban improvements which it is believed will provide a needed lift in promoting this phase of the program to a successful conclusion. For example, a three-phase contract is going on a proposed U. S. Route 40 freeway in Kansas City, the phases covering engineering study, roadway designing, and bridge and structure designing.

Other such projects are under contract in St. Louis, where planning is going forward on an expressway system. There the contracts cover various segments of two of the three proposed expressways. In each case the contracts are aimed at helping speed up final construction on urgently needed facilities as conditions permit.

Just as it did in the Division of Bridges, the adding of 12,000 miles to the supplementary system of highways is putting still more of a load on the Division of Surveys and Plans. With some 5,000 miles of existing local roads already taken over for eventual development as state highways, the survey task here has been one demanding immediate attention — to determine center lines and right of way needs. Several consulting engineer firms and even some county highway engineers have been pressed into service to

complete this part of our work.

In the over-all program, most contracted work has been done by firms actively engaged in consulting engineering services. However, in one instance the District engineer engaged the services of a county engineer and his entire survey party to make needed surveys on supplementary routes. In another, he employed a county engineer and his helper. In this latter case both the engineer and the helper eventually jointed the state highway staff as permanent employees.

When it is decided to use consultants to help in carrying out the expanded program, much care should be taken in drawing up the work contract. A considerable amount of the early difficulties in contracting road work no doubt stemmed from inexperience on such contracts, resulting in failure to picture clearly the scope of the work to be done. Every detail should be set out to the fullest degree. This helps eliminate need for revisions later, cuts out misunderstandings, and speeds completion of the project.

Missouri's contracts carry four specific instances in which the Commission can terminate them. They are:

1. At the termination of any phase of the contract;
2. If the project is abandoned or postponed indefinitely;
3. If the Consultant's services are, in the judgment of the State, unsatisfactory; and
4. If the Consultant fails to prosecute the work with due diligence or fails to complete the work within the time limits specified.

In each of these cases, of course, provisions are made for payment to the Consultant of the value of any service rendered up to the cancellation date, as estimated by the State's Chief Engineer. Thus far, except for the one case cited earlier, it has not been necessary to invoke any of these cancellation causes.

What about the cost? Consultants definitely are more expensive than when the work is done with your own forces. Our engineers agree that, with sufficient personnel to handle all work, they could do it for 35 to 50 per cent of the cost of the contract method. In some cases the savings would even exceed that.

Experience on bridge work has been that consultants will require anywhere from 90 to 200 man hours per sheet to complete bridge design plans. When regular engineering does the work they usually wind up with 30 to 100 man hours per sheet. No like direct comparison is available as yet on roadway design projects.

But, it is understandable why the cost is higher. When Consultants are used you necessarily are paying for their overhead and legitimate profit. Certainly the Consultant must charge not only for services of the engineering and design crews doing the work, but also for services of the company president, vice-president, other officers, secretaries, stenographers, rent, taxes, insurance, standby time, etc.

Again, Consultants are not faced with limitations of a public organization when it comes to bidding for professional services. When they need a larger staff they go into the market and get it. As a result they usually pay higher salaries than can we. Naturally, when you employ them to do a job for you, you pay for their higher salary scale.

This probably represents an exceptional case, but sometime ago bridge engineers saw a work sheet on an estimate prepared by a consultant bidding on a bridge project. It was both revealing and interesting as to how costs

were computed. This sheet fixed the man-hour charge in this case at $7, a figure reached by using $3.33 per hour as the wage scale, then multiplying it by 2.1. Incidentally, after the actual "estimate" of cost had been decided in this particular bid, another 25 per cent then was added to care for "inefficiencies."

Keeping that $7 figure in mind, let's look at an actual example of a job completed by Missouri's own highway bridge forces. This was an especially complex structure, skewed 70 degrees, a long, continuous plate girder span on a horizontal and vertical curve, and superelevated.

Analysis of final design plan cost figures revealed 90 man-hours had been required for each sheet, with the average salary figure at $2.59. The cost totaled less than $4,500, or 2.24 per cent of the final construction costs. It is estimated this same project would have cost approximately 10 per cent of the construction costs had consultants been engaged for the design work.

For another more average design on a skewed structure, regular forces used but 56 man-hours per sheet for the completed design job. Their man-hour cost was $2.25 per hour, with the final total cost being but .93 of one per cent of the construction cost. It probably would have cost about five per cent to have contracted this work.

While no exact comparison is available for roadway design work, one district office prepared an estimate for comparison purposes on one U. S. Route 66 project now under contract. There it was estimated regular forces would require about 400 man-hours per mile to complete the eight mile long project. The same estimate listed 500 man-hours as probable needs of the consultants.

When the consultant submitted his bid on this particular project he estimated about 565 man-hours per mile would be required to complete drawings and design plans. The estimate also fixed 870 man-hours as needed for each interchange and 60 man-hours per mile for preparation of strip maps.

Another cost angle not to be overlooked when consultants are engaged is that supervising engineers still must be assigned to work with the Consultant's crew or crews. Those engineers must be available to advise on the project, to check completed work, and, in some cases, to make revisions. Then, after the design plans are complete, you still must do your own estimating and make up your own specifications.

It is much better, of course, to make contracts on "lump sum" basis. Under such a plan you know exactly, and in advance, what the final design costs will be. Chances for misunderstandings or disagreements on cost amounts are lessened. Thus far all bridge design work has been carried out on that basis. Some roadway work also has been contracted by "lump sum" offers, but more has been by other plans.

On some projects it is next to impossible either for you or the Consultant to estimate in advance to an exact degree what will be required to complete certain work. In some such cases it has been necessary to resort to contracts based on "Unit prices" or on a "cost plus" bid. The unit price plan usually has proved satisfactory, only slightly less desirable than the "lump sum."

No one looks with favor on "cost plus." However, in many instances where great detail is indicated, that's the only method the Consultant will consider. Most experience with such a pricing plan has been on a basis of paying productive salaries plus 100 per cent.

Missouri has used the "Day rate" pay plan, and it hasn't been too unsatisfactory. In one instance, mentioned earlier, a county highway engineer

and his entire crew were retained to survey supplementary roads. They were paid at the rate of $60 per day for the crew. In another case the county highway engineer and his helper were employed on an individual day rate basis. These two, as reported earlier, eventually became permanent employees of the Department.

Nothing said herein is intended to be derogatory in any way to consultants. Far from it. Consultants can serve highway departments well and the sole purpose has been only to present all the facts as to advantages and disadvantages in using their services.

The Missouri State Highway Department is convinced that, with personnel limited as it is, the use of consultants has provided an effective means of helping to solve the problem at hand. By supplementing regular forces with their services the Commission is convinced that it can expand its capacities sufficiently to meet all the demands of the 10-year highway program.

Missouri officials recommend their use by other departments needing such a lift.

PROCEEDINGS PAPERS

The technical papers published in the past year are identified by number below. Technical-division sponsorship is indicated by an abbreviation at the end of each Paper Number, the symbols referring to: Air Transport (AT), City Planning (CP), Construction (CO), Engineering Mechanics (EM), Highway (HW), Hydraulics (HY), Irrigation and Drainage (IR), Power (PO), Sanitary Engineering (SA), Soil Mechanics and Foundations (SM), Structural (ST), Surveying and Mapping (SU), and Waterways (WW) divisions. Papers sponsored by the Board of Direction are identified by the symbols (BD). For titles and order coupons, refer to the appropriate issue of "Civil Engineering" or write for a cumulative price list.

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c. Discussion of several papers, grouped by Divisions.

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